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re: Final report on Award No. AFOSR-87-0213
"Modular Processing Stages of the PIPE Machine"

This grant, for $52,000 was applied entirely for the purchase of:

4 Modular Processing Stages for PIPE (frame buffers expanded 4X-deep),	$53,200
- other funds used for this purchase	- 1,200
Net cost	$52,000

Purchased from Aspex Inc. of New York, NY (formerly Digital/Analog Design Associates).

These 4 stages, combined with the basic PIPE machine including 1 stage plus the ISMAP and support stages (acquired from the National Bureau of Standards), 1 stage purchased with grant funds from Digital Equipment Corp., and 2 stages still on loan from Aspex Inc. *(I still owe them $35,000,* gave us a complete PIPE machine by November 1987.

The PIPE machine has played a very significant role in our research at the Laboratory for Sensory Robotics. Since November 1987 we have developed real-time PIPE algorithms for the following vision tasks:

1. basic feature extraction such as edges, zero-crossings, gradients, orientations, corners, change detection, log-polar transforms;

2. moving object centroid detection and tracking for a binocular robot eye motion system under neural control (using ADALINES);

3. measurement of visual motion (for moving edges) based on the theory of Convected Activation Profiles by Waxman et al.; image velocity fields are updated at 15 times per second;

4. stereo vision matching based on Prazdny's disparity gradient limit "local support" algorithm with depth maps generated once per second;

5. preliminary implementation on PIPE of perceptual grouping of features using the Neural Analog Diffusion-Enhancement Layer (NADEL) concept of Waxman & Seibert. (JES)

6. developed a strategy to implement 16-bit additions, multiplications, and convolutions on the 8-bit PIPE machine;

7. beginning a study of Adaptive Associative Memories on PIPE.

Application #5 is very new and extremely exciting. This neural network is useful for a large number of early vision tasks, and simulations which require about 2 hours on a SUN-3 will require only 10 seconds on PIPE. A detailed parametric study of the NADEL, and its implementation on PIPE is the subject of my recent proposal to AFOSR, Life Sciences Division, entitled: "Parametric Study of Diffusion-Enhancement Networks for Spatio-Temporal Grouping in Real-Time Artificial Vision."

The following publications discuss our work on PIPE:

1. "Progress on the Prototype PIPE" by R. Goldenberg, W.C. Lau, A. She & A.M. Waxman. *Proceed. IEEE 1987 Conf. Robotics & Automation*, Rayleigh, NC, pp. 1267-1274, (1987).

2. "Convected Activation Profiles and the Measurement of Visual Motion" by A.M. Waxman, J. Wu & F. Bergholm. *Proceed. IEEE 1988 Conf. Computer Vision and Pattern Recognition*, Ann Arbor, MI, pp. 717-723, (1988). Extended version submitted to the 1988 Int'l. Conf. on Computer Vision.

3. "Spreading Activation Layers, Visual Saccades, and Invariant Representations for Neural Pattern Recognition Systems" by M. Seibert & A.M. Waxman. *Neural Networks*, in press (1988).

4. "Visual Motion in the Short and the Long: From Receptive Fields to Neural Networks" by A.M. Waxman, J. Wu & M. Seibert. Submitted to the *IEEE 1989 Workshop on Visual Motion*, Irvine, CA (March 1989).

Sincerely yours,

Allen Waxman

Allen Waxman
Associate Professor